

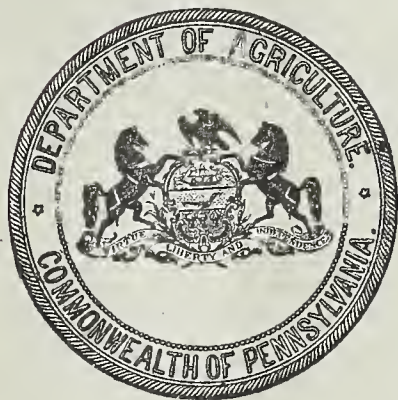
COMMONWEALTH OF PENNSYLVANIA.

DEPARTMENT OF AGRICULTURE.

BULLETIN No. 46.

Some Insects Injurious to Wheat.

By H. T. FERNALD, Ph. D.,
State Zoologist.



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WM. STANLEY RAY,
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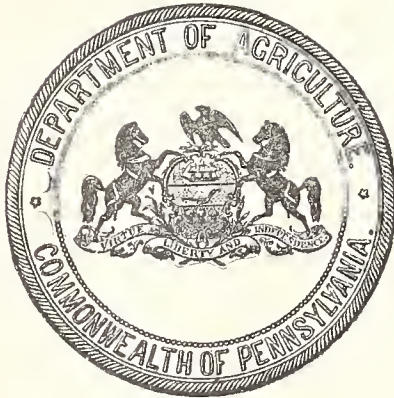
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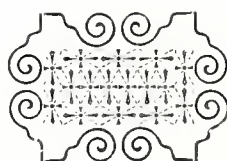
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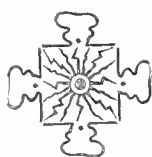
COMMONWEALTH OF PENNSYLVANIA,
DEPARTMENT OF AGRICULTURE,
DIVISION OF ZOOLOGY,
HARRISBURG, PA., *May 10, 1889.*

HON. JOHN HAMILTON, *Secretary of Agriculture:*

Sir: I have the honor to offer for publication the following article on Insects Injurious to Wheat, as one of the Bulletins of the Department. The importance of this crop to the State, and the destruction to which it is subject by the ravages of insects are of themselves a sufficient reason for the publication of any matter which may be of use in reducing the amount of loss to which the people of Pennsylvania are each year exposed.

Respectfully submitted,

H. T. FERNALD,
Economic Zoologist.



SOME INSECTS INJURIOUS TO WHEAT.

Wheat is one of the most important crops raised in Pennsylvania. According to the United States Agricultural Report for 1897, the wheat crop in Pennsylvania that year was 28,259,611 bushels, valued at \$25,716,246, an amount exceeded by but five states in the Union.

A crop of this importance to a state deserves much attention, and particularly when it is subject to serious devastation by insects as was the case in Pennsylvania during 1898. How serious the loss from this cause was, is shown by reports from different counties, which estimate the loss by the Hessian fly at from ten to seventy per cent., the average for the State being thirty-one per cent. If this be regarded as the true loss to the State it represents over seven millions of dollars taken directly from the pockets of the farmers of the Commonwealth by this insect alone, and if, as is probable, a portion of the loss was caused by other insects, it nevertheless represents that much loss, which should, so far as possible, be prevented.

Over fifty different kinds of insects are known to feed upon wheat, but of these, only about ten or a dozen are often sufficiently abundant to cause serious injury. The largest loss in Pennsylvania is usually caused by the Hessian fly, wheat-stem saw fly, wheat-stem maggot, the joint worms, wire worms, wheat midge (often called weevil and Angoumois grain moth to the stored grain, and these will be taken up in some detail.

THE HESSIAN FLY.

(*Cecidomyia destructor* Say.)

This insect was particularly destructive in Pennsylvania during 1898. It is a small fly, somewhat resembling a mosquito, about an eighth of an inch long, with dark wings (See Fig. 1, A, B, and F). It is seldom noticed in this form, however, as the injury is caused by the maggot, which later changes into the fly. It works on wheat both in the fall and spring, there being two main broods each year. It prefers wheat but will live on barley and rye.

Life History.

Each brood occurs in four forms, viz.: egg, larva or maggot, pupa or flaxseed, and adult fly.

The adult flies appear in August and September, and lay their eggs on the leaves of the young wheat plants which have just come up. These eggs are very small, white in color, and are placed on the upper side of the leaf. Anywhere from one to thirty are placed on a leaf, and one fly will lay from one hundred to one hundred and fifty eggs in all. (Fig. 1, C.)

A few days after being laid, the eggs hatch and the little whitish maggots crawl down the blade to the sheath where it surrounds the stem, and then down beneath the sheath and stem to the joint at or below the level of the ground. Here they lie, sucking the juices of the plant and growing, till about the end of November, at which time they are about an eighth of an inch long (Fig. 1, D). They now turn brown and enter the flaxseed stage (Fig. 1, E), doing no more feeding, and in this condition they pass the winter. The following spring, in April or May, after undergoing some changes inside the brown outside shell, they burst this shell and appear as the adult, winged fly.

These flies lay their eggs on the wheat, but usually higher up on the plants than their parents had done the preceding fall, so that the maggots which follow lie near the lower joints which are above the level of the ground. Here they feed for several weeks, then enter the flaxseed stage, in which condition they remain till August or September, when the adult flies appear, to lay their eggs on the winter wheat which has come up.

From this outline of the life history it is evident that the actual injury to the wheat is confined to two periods. The first of these is during the late fall, and the second is during the months of May and June.

It is the two broods, as above described, which cause most of the loss to wheat in Pennsylvania. Occasionally, however, an extra brood may appear and cause some injury. These broods usually appear after the main one in the spring, and before the main one in the fall, and are not generally sufficiently large to cause serious loss. The flies which appear in the early spring rarely spread far, but lay their eggs in the fields of wheat where they themselves passed the winter. It is chiefly the flies which appear in August and September which spread to new fields in which to lay their eggs.

Their Effect on Wheat.

Winter wheat, affected by the Hessian fly, has darker leaves than plants which are not attacked. The central erect stems also, do not develop, and the plants stool out freely. If a plant attacked by the Hessian Fly be pulled up and the leaves stripped down, the little maggots may often be found lying close to the joints, between



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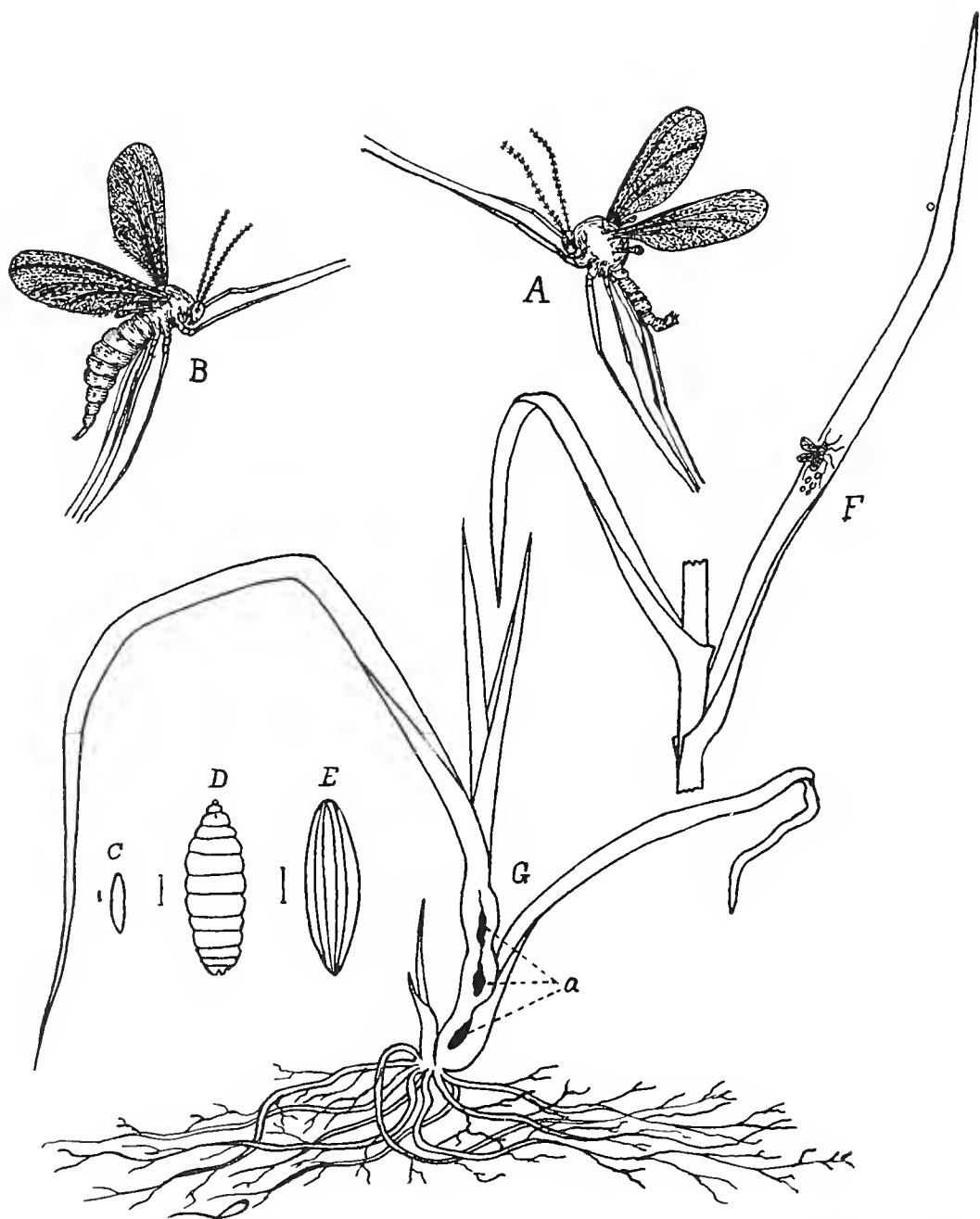


Fig. 1.—The Hessian Fly.—A, Male Hessian Fly, much enlarged; B, Female, also much enlarged; C, egg; D, maggot; E, Flaxseed stage; F, piece of stalk showing fly natural size, laying eggs; G, stalk of wheat injured at *a*, by the fly. The fine lines beside C, D and E show the true length of these stages, the drawings being enlarged.—(Modified from *Riley*.)

the short stem and the leaf sheath which has been stripped down. Late in the fall, injured plants tend to turn yellow and die, either in part or entirely. The injury in the spring is shown chiefly by a weakening of the stems, causing them to fall before harvest time. The grain on such stalks is also usually affected and fails to fill out well.

Origin and Distribution.

The Hessian fly is generally supposed to have been imported from Europe in straw brought over with the Hessian troops during the Revolution, and the common name it bears was given to it on this account. It has been claimed, however, that it was present in this country before that time, and the true facts concerning its appearance in America may never be known. It has long been a familiar pest in Europe, and now covers the wheat raising areas of Europe and America, and in 1888 was reported from New Zealand, thus nearly encircling the globe.

Its Insect Enemies.

There are several insects which prey upon the Hessian fly and aid in checking its ravages. One in particular, which occurs in Europe, is particularly effective, and has been brought to this country and liberated with the intention of establishing it here, to carry on its work. How successful this will be, however, cannot yet be determined.

That these parasites are of value to the wheat grower cannot be doubted, but it is certain that they cannot be relied on to control the fly as they only reduce the loss somewhat, and active measures must also be taken if full crops are desired.

Methods of Treatment.

When the fly has appeared in a field, little can be done to save the crop, though if the wheat can be induced to stool freely, by adding fertilizer, the result will be somewhat bettered. Letting sheep graze on the fields as soon as two or three blades from each root appear, is also beneficial, as the sheep in eating the leaves will be likely to eat some eggs and some of the maggots before they have reached the joints in their downward journey. These methods, however, are only partially effective as remedies, and the best treatment is along the line of prevention.

An excellent method of preventing injuries by the fly, is to plant early a small strip of the field which is to be planted later, the strip thus acting as a decoy. The flies, searching for the young wheat plants to lay their eggs upon, are attracted to this strip and deposit their eggs, after which they die. If the strip be planted about the

first of August, it can be plowed under by the tenth of September, thus destroying all the eggs and maggots in the strip. About the twentieth of September the fields can be planted with comparative safety, as nearly all the flies will have laid their eggs in the trap piece which was plowed under. The exact date at which the fields should be planted varies with the latitude and the season, but should be as late as possible and yet avoid winter killing. These two methods—planting a trap piece early, plowing it under about the middle of September, and planting the fields as late as the twentieth of the month—if used together, and particularly if used by all the wheat growers of a neighborhood, should result in the production of crops almost entirely free from this pest.

Another method of preventing loss has already been indicated. It has been stated that the spring brood of the fly is found near the lower joints of the stem and remains there till August and September. If the wheat be so cut as to leave the stubble rather long, and then after rolling, to break it down, this stubble be burned, the fall brood of flies will be in a great measure destroyed.

When the fly is destructively abundant in certain fields, it is advisable to plant some other crop than wheat the following year, particularly as in general, the system of rotation of crops is an advantageous one.

Volunteer wheat often furnishes a place where the fly can find food for it to complete its life history on, when the main crops are so planted as not to be available for food at the times when needed by the fly. Accordingly all volunteer wheat should be carefully destroyed.

Some varieties of wheat are less injured by the fly than others. Apparently, bearded varieties are less severely attacked than beardless ones, and red varieties less than white ones, although no varieties are entirely fly proof. Varieties recommended on this account are the Clawson, Diehl, Lancaster, Underhill and Mediterranean. Wheat having a natural tendency to stool freely is less liable to injury, as plants which are attacked appear to try to avoid the injury by forming new lateral stems, and varieties which naturally do this, are obviously at an advantage.

Varieties with very strong stems are also advantageous, the straw bending or breaking less readily in the spring, when attacked, than less vigorous varieties.

THE WHEAT MIDGE.

(*Diplosis tritici* Kirby.)

This insect is usually known as the "weevil" in Pennsylvania. When abundant it is a serious pest, often causing great destruction. Fortunately it has not been very abundant in this State during re-

cent years, though scattering reports of its presence in small numbers in 1898 have been received.

According to persons engaged in farming during the years between 1850 and 1860, it was then very abundant and caused much loss, though no reports on its prevalence in this State have been observed.

In New York and Ohio, however, it was a very serious factor for wheat growers for several years. In 1854 the Secretary of the State Agricultural Society of New York, gathered data from all parts of the state from which he estimated the loss that year, from the ravages of this insect, at about fifteen millions of dollars, and if the price to which wheat afterwards rose that winter had been taken into consideration, the loss would have been at least one-third greater.

During 1856 and 1857 this insect extended its operations over a larger part of the State and the loss in 1857 was considerably more

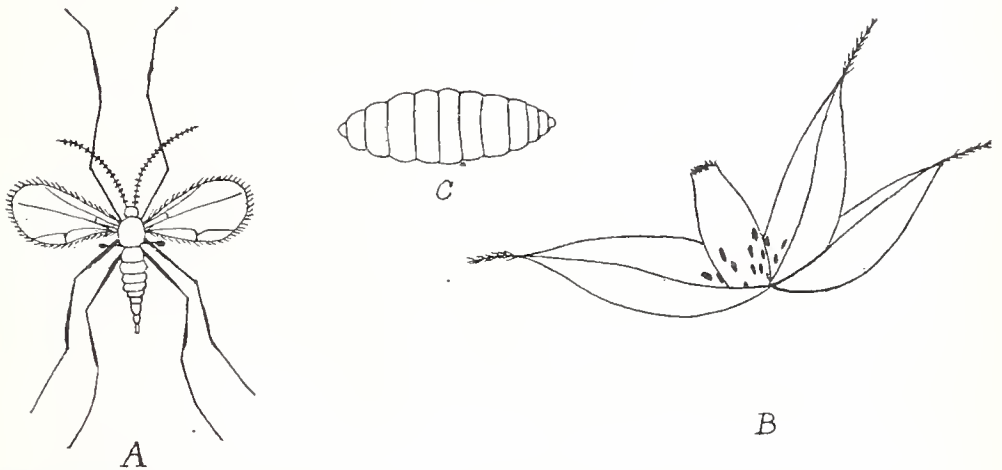


Fig. 2.—The Wheat Midge. A, Adult Midge; B, a wheat flower showing the maggots around and on the kernel; C, maggot when quiet. All much enlarged. (Modified from Fitch.)

than fifteen millions of dollars. In Canada the same year it destroyed about eight millions of bushels. In 1856, in Livingston county, New York, two thousand acres, on flats which would have yielded thirty bushels an acre, were not harvested at all.

Ohio was also invaded during these years, and the loss there was estimated at being even greater than in New York.

With these facts, showing the enormous loss which may be incurred if this insect at any time becomes abundant, it is important that its appearance be watched for and appropriate treatment be adopted to check its further increase and spread.

Life History.

The adult wheat midge or weevil is a small fly, closely related to the Hessian fly and somewhat resembling it, except that the wings are not dark. It appears about the time the wheat blossoms de-

velop in the spring and in these it lays its eggs. The eggs hatch in a short time, producing minute maggots, at first colorless, but later becoming orange. These maggots lie between the wheat grains and the surrounding chaff, and suck the juices, causing the grains to shrivel up. After about three weeks they leave the head and pass into the ground where they turn brown and become quiet. In this condition they pass the winter and after some internal changes, appear the following spring.

Some of the maggots fail to leave the heads of wheat and are carried with these to the stacks, thus infecting the places where the winnowings gather at threshing time. As such individuals can become adult flies, even though they have not been in the ground during the winter, this must be remembered when methods of treatment are being considered.

Origin and Distribution.

Like the Hessian fly, the wheat midge is a native of Europe. It appeared in this country about 1820, being first noticed in Vermont, whence it spread in all directions.

Insect Enemies.

These are apparently of little effect, and where the midge is abundant, the wheat grower must depend on his own efforts to control the pest.

Treatment.

In the life history of the insect the full grown maggot passes into the ground to pupate, just before, or about the time of harvesting. At this time, then, part will be found in the ground and part in the harvested grain. To destroy those in the ground it is advisable to plow deep, soon after the grain is cut, thus carrying those in the ground so deep that they will either be crushed or at least be unable to reach the surface the following spring. Those which remain in the grain usually gather with the chaff and "tailings" from the threshing machine, and if this refuse be carefully swept up and burned, not only will a larger proportion of the midges be destroyed, but also the seeds of many undesirable weeds. Although this will not save the crop attacked, by the application of these methods, the following crop will probably be protected from the ravages of this insect to a considerable degree.

THE WHEAT-STEM MAGGOT.

(*Meromyza americana* Fitch.)

The wheat-stem maggot was known from Pennsylvania as early as 1821, at which time it was reported from Bucks county. In habits



Fig. 3.—The Wheat-stem Maggot. Adult fly above at left; injured stalks of wheat; piece of stalk split open showing maggot at work; maggots enlarged, and a parasite. Fine lines beside the figures show the true length. (From *Lugger*.)

and appearance it sufficiently resembles the Hessian fly to mislead those who do not examine it closely, and in consequence, much of the injury it causes is supposed to be produced by the fly. From specimens received, it is probable that the wheat-stem maggot is present every year in this State, and is the cause of considerable loss to the wheat crop.

Life History.

This insect feeds not only on wheat, but also on various grasses, barley and oats. The adult fly (Fig. 3), appears in the wheat fields in September and deposits its eggs on the young wheat plants. The little maggots which soon hatch from these eggs pass down the plant to a joint just above the bulb, where they remain, sucking the juices from the stem, which is short as yet, and causing it to become discolored and then to die. This process is usually completed by the time the winter sets in and the maggots pass the winter in this place. In the spring, after pupating, the adult flies appear and lay their eggs for the next brood.

The maggots which hatch from these eggs pass to the upper joint of the wheat stalk, just above which they lie, between it and the leaf sheath, and suck the juices there. The effect of this is to cause that part of the stem to wither and dry up (Fig. 3). The effect on the head is similar. Describing some heads thus injured, Prof. Lintner (First Report, p. 222, 1882), writes: "The heads were entirely destitute of kernels. Within some of the husks the remains of the blossoms were discovered, showing that their development had been arrested before the formation of the grain. Upon removing the investing sheath, the stem was found to be discolored and shrunk and quite dry for three or four inches above the joint, and near the joint it was so eaten and shriveled as to be utterly useless for the purpose of carrying the sap." From the maggots of the spring brood which thus destroy the heads, the adult flies appear about harvesting time and lay their eggs on grass and volunteer wheat. The brood thus produced completes its life history by the appearance of the flies from it in September to lay their eggs on the new winter wheat as already described. Thus, there are three broods each year—one appearing in September, one in the spring, and one in July. Of these, the first two chiefly attack wheat, while the third lives on grasses and such wheat as it may find during midsummer.

Effect on Wheat.

The injury to wheat, caused by the fall brood, is perceptible only on the short, central stems of the little plants, which would otherwise form the main stalks the following spring. In plants where the

wheat-stem maggot is present, these stems become discolored and dead.

The injury caused by the spring brood is more noticeable. Some little time before the wheat should be ripe, the heads and upper portions of the stem turn white—a condition sometimes described as the “Silver-top of Wheat.” Such heads are quite noticeable when the insect is abundant, and examination of affected stems will show that just above the upper joint the stem is shrunken or even severed and the little greenish maggot which caused the trouble will sometimes be found there.

Origin and Distribution.

This insect is probably a native of America and is known from Canada to Texas, and westward, probably to the Rocky Mountains. Its distribution appears to be quite general.

Enemies.

Only two enemies of this insect have thus far been reported. One—a little parasite having no common name—has been found to be present in considerable abundance in some parts of the country. The other is a very small mite which infests the maggots. Both of these are decidedly beneficial, but the very fact that despite them, the wheat-stem maggot often causes considerable destruction, shows that as checks to the increase of this insect they are insufficient.

Methods of Treatment.

Treatment for this insect is unsatisfactory at best. Living, as it does, in the straw at the upper part of the stalk, it is not left in the stubble to be plowed under, nor does it usually go to the stack with the straw, but leaves it before harvesting.

The point in the life history at which the wheat-stem maggot can most successfully be attacked is the summer brood. Feeding as it does, on volunteer wheat and grasses, it would probably do much good if strips of decoy wheat were planted immediately after harvest, so that the summer brood could develop there. Then early in August destroy this wheat and also all volunteer wheat. Late planting, as recommended for the Hessian fly, might also be of some use, but as the adult flies have been found in October, this method would be only partially successful at best.

Hand picking of the noticeable “Silver-tops,” cutting them off below the upper joints and burning them, would certainly be of value, but is of rather doubtful utility in practice.

Certain varieties of wheat are less often attacked by the insect than others, and where the maggot is very abundant it would be wise to bear this in mind for subsequent seedings.

THE JOINT WORM.

(Isosoma hordei Harris.)

This insect is occasionally injurious to wheat in Pennsylvania, and its attacks are usually confused with those of the Hessian fly. It is a very small insect, about an eighth of an inch long when adult, with four wings, and has been compared in general appearance to a small ant.

Life History.

The adult insect lays its eggs near one of the lower joints of the stalk about the last of May or first of June, boring a little hole in the stem in order to do this. The young larvae which hatch from these eggs lie in little cavities and extract the sap, thus preventing the proper growth of the parts above, and causing the stem where they are to form little galls, and become hard and woody. When the attack is serious the stalk is swollen and bent over at this place. Here they spend the summer, and in the fall become pupæ and pass the winter, and escape by little holes in the sides of the galls, as adults the following spring in time to lay their eggs on the wheat of that year.

There is but one brood a year. They attack wheat, rye and barley.

Distribution.

The joint worm is probably a native of this country and was first reported between 1820 and 1830, from Massachusetts, where it did much damage. Subsequently it appeared in Virginia, causing serious losses. Since that time it has appeared in nearly all the Eastern states and Ohio, while closely related forms attack grain in a somewhat similar way farther west.

Parasites.

There are several insects which prey upon this pest and are of much service to the wheat grower.

Treatment.

As the entire life of the joint worm, except its adult state, is passed in the stalks of the wheat, any method which will destroy these will be successful. The best plan to follow, usually, is to cut the infested fields rather high, to leave as much of the lower part of the stems as possible in stubble, then burn this. Plowing under is also a good method, except that it is difficult to plow deeply enough to prevent the insects making their way to the surface in the spring.

Many of the hardened pieces of straw are broken off in threshing and are carried by their weight with the grain from the threshing machine. These should be gathered and burned.

THE WHEAT-STEM SAW FLY.

(Cephus pygmaeus L.)

This insect has long been known in Europe as an enemy to wheat and rye, where it has caused much injury. In this country it has made its appearance in widely separated localities, but thus far has been less injurious than abroad.

Life History.

The adult insect, which is about a third of an inch long, lays its eggs inside the stem, cutting a hole through for this purpose. The egg is usually laid in the upper part of the stem, some time in May. The young which hatches from the egg eats its way downward, feeding on the substances of the joints and on the inside tissues of the stem. In this way it works down until about harvesting time, when it is usually at or near the lowest joint; here it eats a circular ring in the stalk, leaving only the very outside to support the upper portion. It now spins about itself a delicate case (cocoon) and remains quiet until the following spring, when it undergoes some internal changes to become the adult which now appears, to lay its eggs as before.

The injury caused by this insect is of two kinds. The eating of the centers of the joints and of the inside layers of the stem prevents full development of the heads. Later the cutting of a circular ring near the lower joint so weakens the stem that this is likely to break off and cause the affected stems to fall where they cannot be reached in harvesting.

Distribution.

As already stated, the wheat-stem saw-fly is a native of Europe. Just how it was brought to this country is not known, but as it sometimes does not reach the lower joints before the grain is cut, it is possible that it was introduced here in straw used as packing, which contained some of the cocoons. In America it has been reported from New York, Canada and Manitoba, and its presence is suspected in Ohio and West Virginia. Accordingly it may be met with in Pennsylvania at any time.

Parasites and Treatment.

Little is known of parasites in this country, though such occur in Europe. As the insects, with few exceptions, pass the winter in the stubble, however, the treatment is simple. Either burn the stubble or plow it deep, after harvest, to destroy the insects in it. If the insect ever becomes serious it would also pay to burn the straw after threshing also, to destroy those which, having failed to get down to the stubble, have been harvested in the stems.

THE ARMY WORM.

(Leucania unipuncta Haw.)

The army worm is a very serious pest, not alone to wheat, but to many other crops as well. Its preferred food is the leaves of some grass, and accordingly wheat and oats are favorite articles of diet. On the other hand, the insect will eat many other plants and cause much injury. It has been known to feed on the leaves of clover, peas, strawberry, apple, cucumber, cranberry, asparagus and onions as well as barley and rye and other crops. Such omnivorous feeders are always to be feared, especially when abundant, and it is fortunate that they are seldom seriously numerous for more than a year or two in any one place.

Life History.

This insect passes the winter either as the adult moth, the caterpillar, or possibly as the pupa. In either case the adult stage is reached in the spring and the eggs for the first brood are laid. The caterpillars which hatch from these eggs, feed, grow, enter the ground and pupate and the moths they produce appear in June. These moths lay eggs for the second brood (which is usually the one which, while in the caterpillar stage, causes most damage about the middle of July). These caterpillars pupate about the end of July and the



Fig. 4.—The Army Worm Moth, natural size.

moths from them appear in August and lay their eggs for the third brood. Sometimes it is the caterpillars from this brood which are destructive, but more often the most serious injury is caused by those of the second brood. The caterpillars of the third brood feed and generally succeed in reaching the adult (moth) stage before winter, though some usually fail to progress so far and spend the winter either as caterpillar or pupa. A fourth brood may possibly exist in southern Pennsylvania. (See Fig. 4.)

Injuries.

The first or spring brood of caterpillars usually feeds unnoticed, eating holes in the leaves and dropping to the ground when disturbed.

When the food in their immediate neighborhood is all consumed, however, the caterpillars must search for more—something that does not occur in most years, as they are not often sufficiently abundant to eat all the food, even in the second brood. When, however, they are so abundant as to exhaust all their food supply, they set off together, forming the armies which have given them the name “Army worm,” to find new pastures. This usually occurs with the second or third broods, rather than the first. As they reach new fields they strip them as they go. Finally, when they have fed enough, they seek sheltered places and, either under the leaves and grass or just below the surface of the ground, they change from the caterpillar to the pupa stage, from which after a time the moth emerges.

The injuries, as this outline indicates, are caused by the caterpillar feeding. This occurs three times each season, but individuals of the first brood are rarely abundant enough to do a noticeable amount of harm. The second brood, if sufficiently abundant, will strip the field where it is, then pass to other fields to repeat the operation, though this process may not take place till the third brood has appeared.

Distribution.

The army worm is widely distributed, being found in many parts of the world. It is known to occur nearly all over the United States, in certain islands of the West Indies, in South America, England, Java, Australia and New Zealand.

Parasites.

Fortunately this insect has a number of parasites which attack it, and it is probably due to this that destructive “raids” do not often occur two years in succession in the same locality. Two flies in particular, attack the insect and are sometimes so abundant in fields where the army worm is present as to produce a noticeable buzzing. In all, about twenty insects are known to prey upon this pest and are of much benefit in preventing its continued ravages.

Treatment.

If a field has become thoroughly infested by army worms, there is little which can be done. As the insect passes the winter in sheltered places, under grass and rubbish, burning such places, es

pecially along the fences, late in the fall, will destroy many. Birds, particularly our song birds, are believed to feed freely on the army worm, and they should be protected by the farmer and encouraged to breed.

When it is noticed that the insects have begun to strip the fields, a bran mash is sometimes used successfully. This is made by mixing thirty-five pounds of wheat bran, one gallon of molasses and one pound of Paris green in hot water enough to make the mash properly thick. This is scattered over the field just before night and usually succeeds in inducing many of the caterpillars to feed upon it rather than upon the crops and kills them.

When the caterpillars have begun to march in search of food, other methods to protect exposed fields may be used. One way to do this is to plow a furrow across their line of march, with the land side of the furrow toward the field to be protected. By this method the caterpillar must first crawl over the loose earth turned up, then over the bottom of the furrow and finally up the perpendicular side of the furrow. If, at intervals of about ten feet, holes be dug in the bottom of the furrow, many caterpillars will collect in these and die. The holes should be about two feet deep and a couple of inches in diameter, and can be made with an auger such as is used for making fence-post holes. If straw be plenty this can be scattered along in the furrow and burned when the caterpillars have thickly covered it, or a band of tar in the same place may be used to hold the caterpillars fast. Two furrows, a few feet apart, are still better.

A field may often be protected by heavily spraying a strip at the edge which the caterpillars are approaching, with Paris green and water, or sprinkling it with Paris green and lime mixed. The caterpillars feed on this strip, are poisoned, and die. Care should be taken, however, if this plan is followed, that this portion of the field be not cut and fed to stock but destroyed.

These are the best methods for controlling the army worm, but where it becomes sufficiently abundant to travel in armies, the field from which it travels is usually an entire loss, as the insect can be kept out of a field much easier than it can be gotten out of a field which it is already in.

WIRE WORMS.

These are the young of the "Click beetles," or "Snapping beetles," as they are sometimes called, from the power they have, when placed on their backs, of "snapping" themselves into the air in order to turn over and alight on their feet. There are a number of kinds, but they all injure the roots of crops in the same way, by feeding on them.

Life History.

The eggs are laid in the spring and the little wire worms which hatch from them feed upon the roots of plants. They grow slowly and often require several years to reach their full size. When this has been attained they become quiet and undergo internal changes

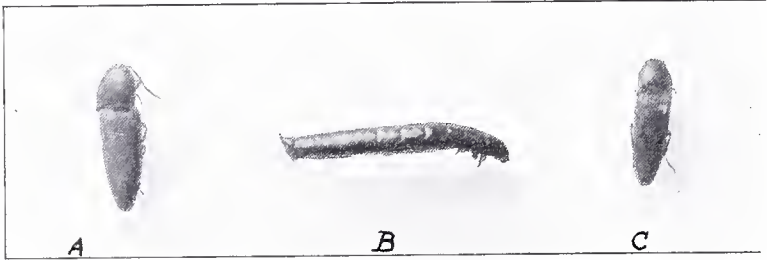


Fig. 5. — Wire Worms. B, side view of a wire worm; A and C, adults of wire worm (click-beetles).

(pupation), and the following spring the adult beetles appear. This pupation and the production of the beetle as a result, usually takes place in the fall, but the beetles generally remain where they are until spring before coming to the surface of the ground. (See Fig. 5.)

Treatment.

Though in exceptional cases, treatment by insecticides may be successful, as a usual thing other methods are more effective. Plowing late in the fall will bring most of the pupæ and adult beetles up where they will be exposed to and killed by the winter weather, and though this will not destroy the insects in the wire-worm stage, yet, if repeated for several years, the insects will be gradually reduced in numbers till they are so few as to do little damage.

Rotation of crops is also a good way in which to check the wire-worms, especially if the land be kept only one year in grass and be not directly followed by potatoes and corn. Kainit for fertilizing is believed by many to be destructive to the small wire-worms, and on this view the treatment, particularly in light soils, should be as follows: "Plow in fall; in spring, after cultivating and preparing for the new crop, fertilize heavily, using kainit for potash, and nitrate of soda, so far as possible, for nitrogen. At least one thousand pounds of kainit per acre should be used. The fertilizers will not prove satisfactory unless applied as directed, i. e., in one heavy application, and when the ground is bare." Fall plowing, repeated for several years, is the most certain remedy.

THE GRAIN APHIS OR WHEAT LOUSE.

(Siphonophora avenae Fab.)

The grain aphis occurs widely, both in this country and in Europe. It is present nearly every year in our grain fields, but not often in such numbers as to be a serious pest. It feeds on all the important grains, and also on many of the grasses. It first attracted attention by its injuries to grain in this country in 1861 in New York. During that year it was also destructive throughout a large portion of New England, in northeastern Pennsylvania, and in Canada. Since then it has from time to time appeared in injurious numbers in different parts of the country.

Life History.

The life history of this insect is only partly known, no males ever having been found. In the spring the aphids may be found on the

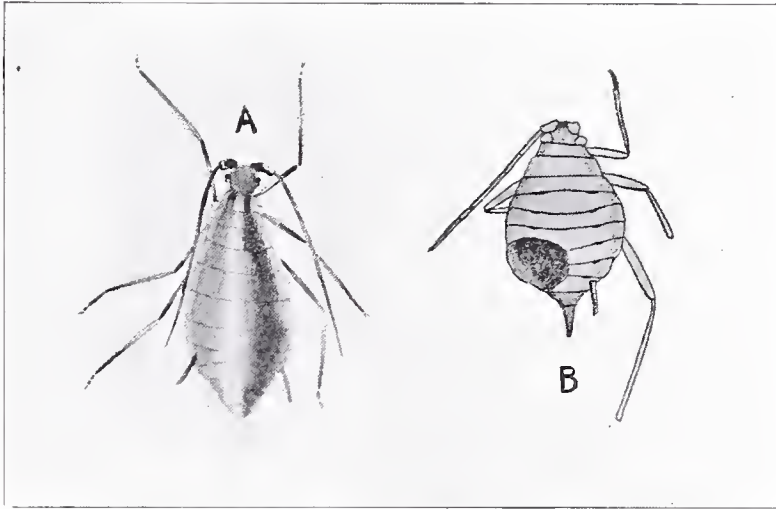


Fig. 6.—Grain Aphis. A, Wingless adult; B, Aphis which has been attacked by parasites. Both figures greatly enlarged. (A, after Fitch; B, after Smith.)

leaves and stalks of the wheat, sucking the juices by means of their slender beaks (the rostrum). At this time they are green in color and somewhat resemble their relatives so common on rose bushes. They are scattered about over the plant, are wingless, and produce young which are born alive, usually about four per day. These in turn produce young when three or four days old, “so that the descendants of a single aphis will in about twenty days number almost two millions.”

About the end of May winged forms also appear and these are able to fly to other fields to attack the grain there.

When the heads of the grain begin to form, the aphids leave the other portions of the plant and gather here, sucking the juices and either in part or entirely preventing the filling out of the kernels. They now change their color, becoming orange, and after a time turning towards yellow or red.

What becomes of the insect after the grain is cut is uncertain but it is probable that it passes the late summer and fall on some other food plant.

Parasites and Treatment.

Treatment for this insect is at best unsatisfactory. Though salt, soot and other remedies have been proposed, the difficulty in applying them to infested fields prevents their practical use.

Fortunately, however, parasites are active in attacking these insects, some feeding within the body of the aphid and escaping when full grown by a little hole in the back.

Lady-bugs also attack this aphid, finding it a very satisfactory article of food, and one lady-bug would probably be able to clear an entire head of wheat in a short time. It is due to these friends that the grain aphid is seldom injuriously abundant.

THE ANGOUMOIS GRAIN MOTH.

(*Sitotroga cerealella* Oliv.)

This little moth has long been known in this country though it takes its name from a province in France where it has caused much loss. It is most injurious in the South, though in parts of Pennsylvania it is often a very serious pest. It works on the grain itself, eating the inside of the kernel, like the weevils for which it is often mistaken.

Life History.

Though there are but two broods a year of this insect in its natural surroundings, its life within doors enables it to increase this number if the temperature where the grain is stored is sufficiently high, which fact should be kept in mind.

The moth appears in spring, usually in May or June, and passes to the grain fields to lay its eggs. In the case of wheat, these are usually placed in the furrow on the side of the grain itself, and as each female moth lays from sixty to ninety eggs, the number of grains infested is considerable if the moths are abundant. When the eggs hatch, the little caterpillar burrows into the grain and feeds within it for about three weeks. About this time it has grown to be about one-fifth of an inch long, and little is left of the grain except an outside shell. It now cuts a small circle somewhere in

the shell, nearly all the way around, but leaves just enough uncut, so that the piece does not drop out and leave a hole. The caterpillar now spins around itself a silken covering (cocoon) within which it undergoes the changes of structure necessary to build the caterpillar over into the adult moth. These changes having been completed, the moth leaves the silken cocoon, pushes out the circular portion of the surface cut by it when it was a caterpillar and appears outside of the grain.

The moths which appear in this way are present during August and accordingly in the case of winter wheat, after harvesting. Hence they find themselves either in the stack, before threshing, or if threshing has already taken place, wherever the wheat was stored. The moths now lay eggs for a second brood which has a similar history, and if cold does not prevent, a third or even a fourth brood may be produced. In Mississippi it has been stated that "there are at least eight annual generations" of this insect. During 1898, the moths appeared in infested wheat received by me from Montgomery county, and the bottle containing the wheat having been kept in the house, three generations appeared between that time and January, 1899, showing that under favorable conditions, brood will follow brood at intervals of a little more than a month.

The insect probably passes the months during which it is too cold to feed and undergo its changes, in whichever form it may happen to be when the cold comes on.

Injuries.

The injury to wheat is of course directly in proportion to the abundance of the insect.

During the fall of 1898, Montgomery county and neighboring counties lost a large portion of the wheat which had escaped the unusually severe attacks of the Hessian fly, in this way.

Not only is the loss great to seed wheat, but flour made from wheat which has been infested by the grain moth, is of very poor quality, and (it is said) may even cause a dangerous throat disease to persons who use such flour.

The Angoumois grain moth also attacks corn, oats and barley, and often causes much loss to these, particularly to corn.

Distribution.

The original home of this insect is unknown. It occurs in the central and southern parts of Europe, in England and Australia, and through the Eastern, Middle and Southern States in this country and is sometimes met with in Canada. It is less destructive in the North, the cold weather there checking its ravages earlier in the fall.

Parasites.

Two parasites—a mite, and an insect known as *Catolaccus*, and having no common name—prey on the Angoumois grain moth. The latter was quite plenty last fall in Montgomery county, and did considerable good. It was not sufficiently abundant, however, to prevent much loss.

Probably little or nothing can be done to prevent the ravages of the first brood of the grain moth when it is in the fields. But when the wheat has been reaped, successful treatment is possible.

It is important where the grain is infested, to thresh the wheat as soon as possible after it is harvested, as it is not feasible to successfully treat the wheat in the stack. When the wheat has been placed in bins, several methods for the destruction of the moth are available. Among these the application of heat (at about 165 degrees Fahr. for an hour), spraying the grain with kerosene, and fumigating with sulphur, have all been recommended. But the method which is best, because the simplest, is to use carbon disulphide, which can be obtained at drug stores at twenty-five or thirty cents per pound. In using this chemical, care should be taken that the bin the infested grain is in is tightly closed at the sides and bottom.

The method of procedure is as follows: See that the bin is tight, except at the top, where it does not so much matter; place the carbon disulphide in shallow dishes (soup plates are good for the purpose), on top of the grain, and cover the bin. If the bin has no lid, a heavy horse blanket or any covering which is fairly tight will do. Leave the bin thus treated for twenty-four hours, during which time the carbon disulphide will have passed off as a gas, and being heavier than the air, will have descended through the grain and destroyed the insects. After treating in this way for the above time, remove the cover and examine the grain for signs of life anywhere in the bin. If any insects are found alive, stir over the grain to bring another portion to the top, and repeat the treatment. This will not usually be necessary, however.

A kerosene barrel is very good to fumigate small quantities of grain in sacks, in.

The amount of carbon disulphide to be evaporated depends on the amount of grain. From a pound to a pound and a half to each ton of grain is the usual amount, but as it is generally easier to measure the size of the bin than to weigh the grain it contains, the following may be taken instead: Evaporate one pound of the carbon disulphide for every thousand cubic feet of space. For example, if the bin measures 10x10x10, use one pound, divided between three shallow dishes; for a space 10x10x20, use two pounds in six dishes; for

a space 10x20x20, use four pounds in twelve dishes, and at a similar rate for larger places.

One caution is necessary. Carbon disulphide catches fire very easily; so, while the gas remains, no light or fire, not even that of a pipe, should be brought within several yards of the bin.

THE GRANARY WEEVIL.
(*Calandra granaria* L.)

This insect is a true weevil, having a snout and feeding within the grain, like the Angoumois grain moth. It has long been known, and has found its food in granaries for so long a time that it has lost the use of its wings and is unable to fly.

It attacks wheat, barley, oats, corn, etc., feeding on them both as the adult beetle and as the larva or grub.

The insect is very prolific, and it has been calculated that the descendants of a single pair will number six thousand in a single year.

Life History.

The adult beetle makes a hole in the grain with her snout, and in this places an egg. From this hatches a legless grub or larva,

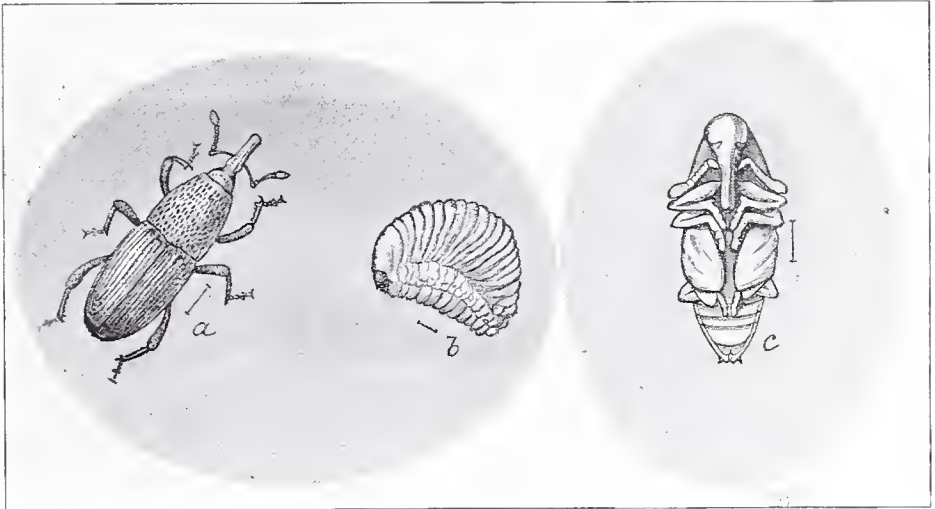


Fig. 7.—The Granary Weevil. *a*, Adult beetle; *b*, grub; *c*, pupa. The fine lines beside the figures show the real length of the insect in the three stages. (Modified from Chittenden, Farmers' Bull. 45, U. S. Dept. Ag.)

which feeds on the contents of the grain and passes through its different changes till the adult beetle is produced. The time required for this process to be completed varies according to the temperature, it being about six weeks in summer. It is probable that there are four or even five broods a year in the latitude of Pennsylvania. The adult beetle also feeds on the grain and probably does as much damage as the larvæ.

Treatment.

Treatment for this insect should be by the carbon disulphide method as given for the Angoumois grain moth.

While there are many other insects which injure wheat, those here treated of are the ones most likely to cause trouble in Pennsylvania.

